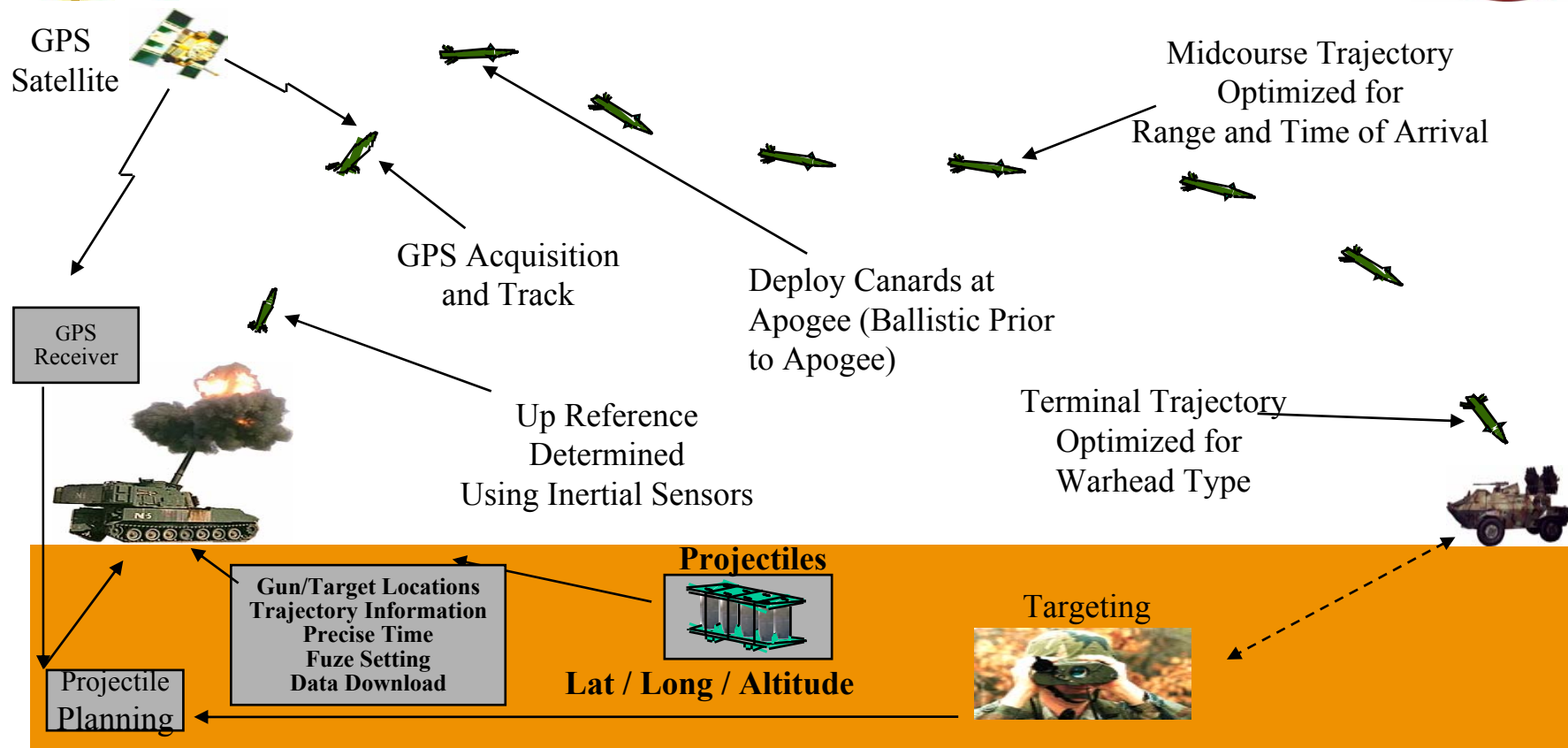


Smart Munitions and HSTSS

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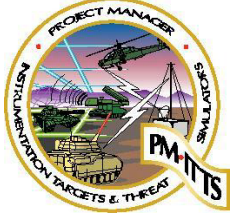
Working Towards Embedded Instrumentation

Briefing by: *Dennis Schneider, PEO STRI*
(407) 384-3902

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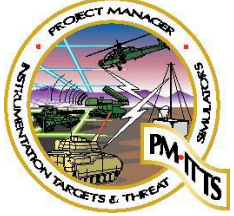
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Background

- *HSTSS project was funded by OSD CTEIP, Army Sponsored and External Customers (i.e. CRADA's)*
- *HSTSS is a **multi service** instrumentation development program*
- *HSTSS is a low cost, micro miniature, high g (100,000 g) **modular** instrumentation system*
- *Products being delivered that allow for integration at all levels*



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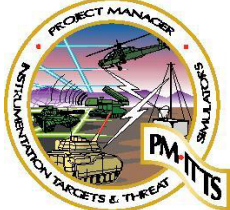
Embedded Instrumentation Philosophy

- *Design at Concept Formulation*
- *Choose Electronic Technology
Similar to Actual Platform*
- *Qualify During Early Flights*
- *Instrumentation Evolves with Platform*
- *Instrumentation for DT, OT, Tactical
and Training*

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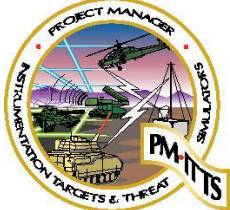
HSTSS Efforts

- ***Transmitters***
- ***Programmable Logic Devices /
Pulse Code Modulation Encoders***
- ***Packaging***
- ***Batteries***
- ***Sensors***

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Today's and Next Generation ^{DRAFT} *Transmitters*

Transmitter Architecture

- Programmable, multimode and multiband
- Efficient Complex Amplitude and Phase modulation
- Digital interface and control

Much Lower Cost and Reusable building blocks

- Two chip solution cost and size benefit

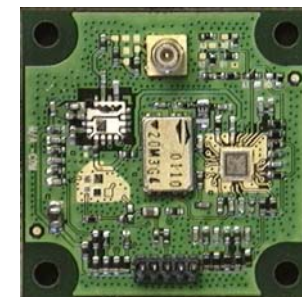
Integrated transmitter, processor, and antenna solution

Modulation-independent transmitter solutions

- FM, GMSK, QPSK, HPSK, OFDM
- 10kbps to 10Mbps
- L & S and ISM Bands



Non PLL Transmitter
(15 mm, ARL Design)



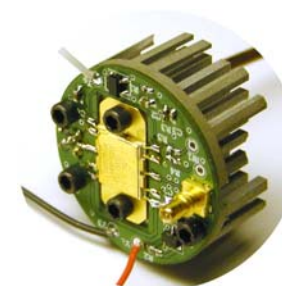
0.5 mW Transmitter
(28.6 mm)



1 Watt FIU Transmitter
(1.75 x 3 Inch)



0.25 mW Transmitter
(28.6 mm)

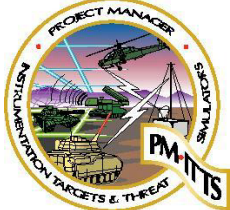


1 W or 2 W Support Board
(28.6 mm)

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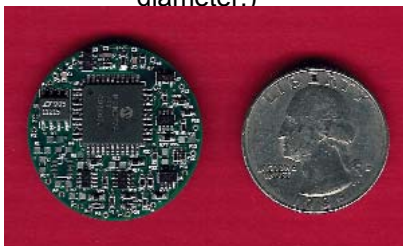


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PLD Encoders

The **HSTSS** IPT has developed several g-hardened encoding and signal processing devices utilizing various programmable technologies, including Field Programmable Gate Array Complex Programmable Logic Device (CPLD), and PICmicro controller technologies. Designs are configurable for analog channel count, bits/word, update rate, and accommodation of digital inputs. Signal delay is currently being incorporated into an encoder board design.

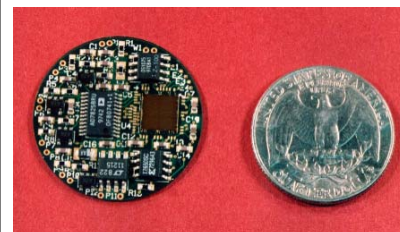
PICmicro based PCM Encoder module (1.125" (28mm) diameter.)



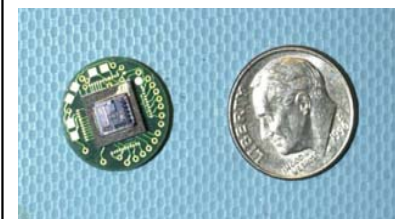
FPGA PCM Encoder Board Measures 2" X 4"



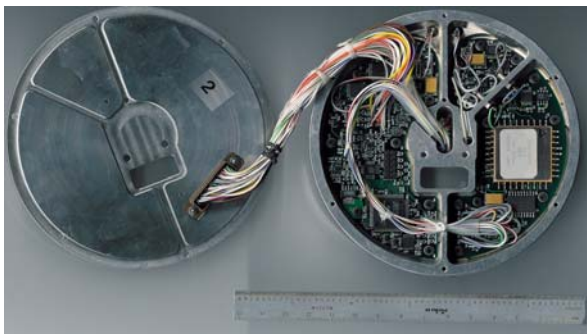
FPGA based PCM Encoder (1.125" (28mm) diameter.)



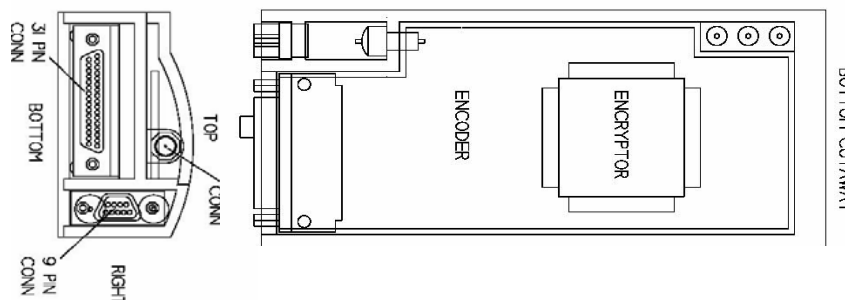
CPLDbased PCM Encoder (0.75" (15mm) diameter.)



Systems with Utilizing HSTSS Technologies



Excalibur Program

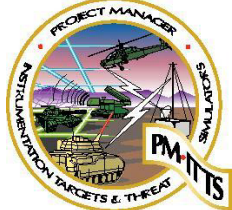


ERGM Program

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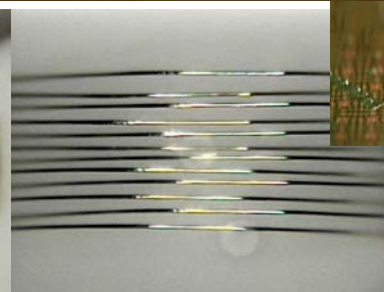
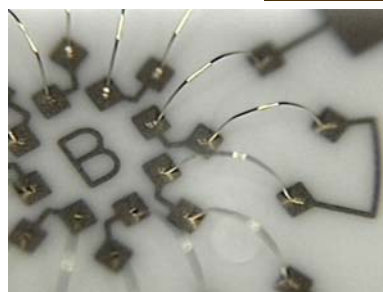
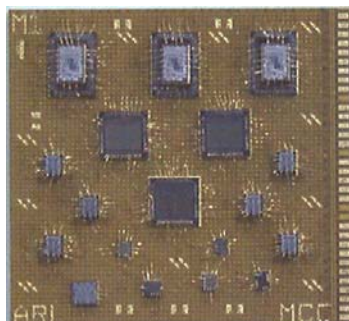
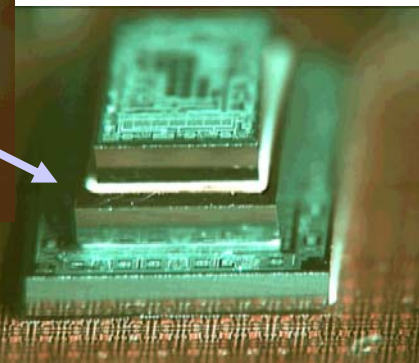
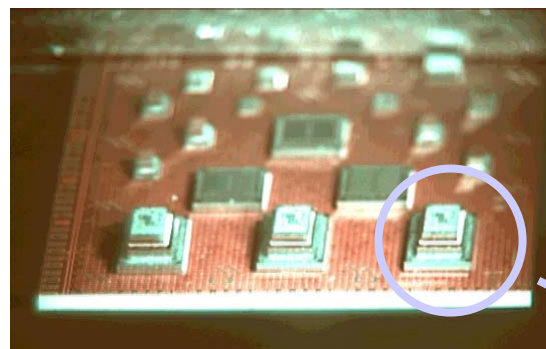
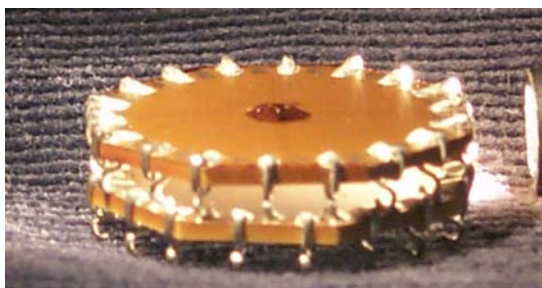


Advanced High-g Packaging

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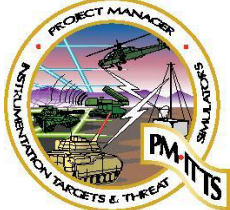
- Establish & qualify microelectronic assembly techniques for ballistic environment
 - Establish boundaries
 - Adopt & modify commercial techniques
 - Address substrate materials, adhesives, interconnect, etc.



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Air-gun pre-qualification tests with HSTSS batteries

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Ultralife Lithium Ion NF Cells

Nominal Voltage: 4V

Cell Dimensions: 0.99" x 0.99" x 0.195"

Typical Discharge Current: 250 mA



Ultralife Li/MnO₂ NF Cells

NF1 - single cell

NF3 - 3-cell battery

Nominal Voltage: 24V

Cell Dimensions: 0.98" x 0.98" x 0.14"

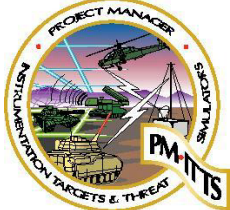
Typical Discharge Current: 250mA

- Ultralife Lithium Ion and Li/MnO₂ tested at 50, 80, and 100 kg's (nom.)

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Li/MnO₂ Cylindrical Cells

Airgun Testing

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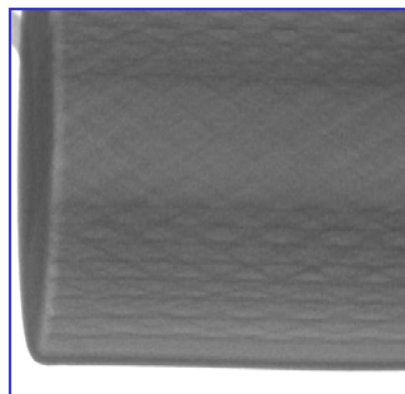
Typical
Duracell CR2

Airgun Test Summary

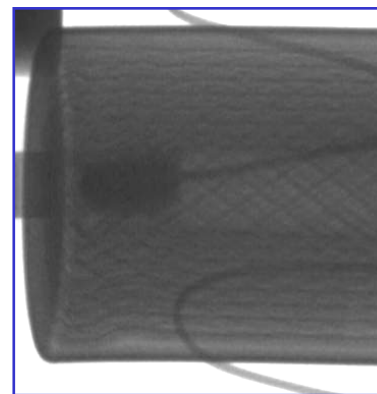
vertical orientation

2 cells at 60kG
no failures

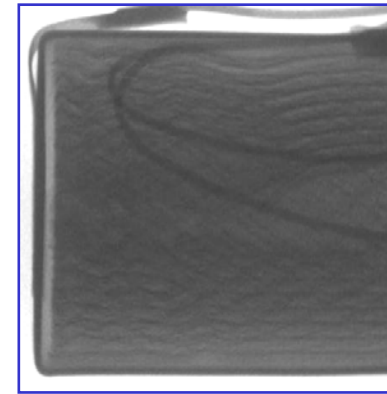
4 cells at 100kG
1 failure



Unshocked

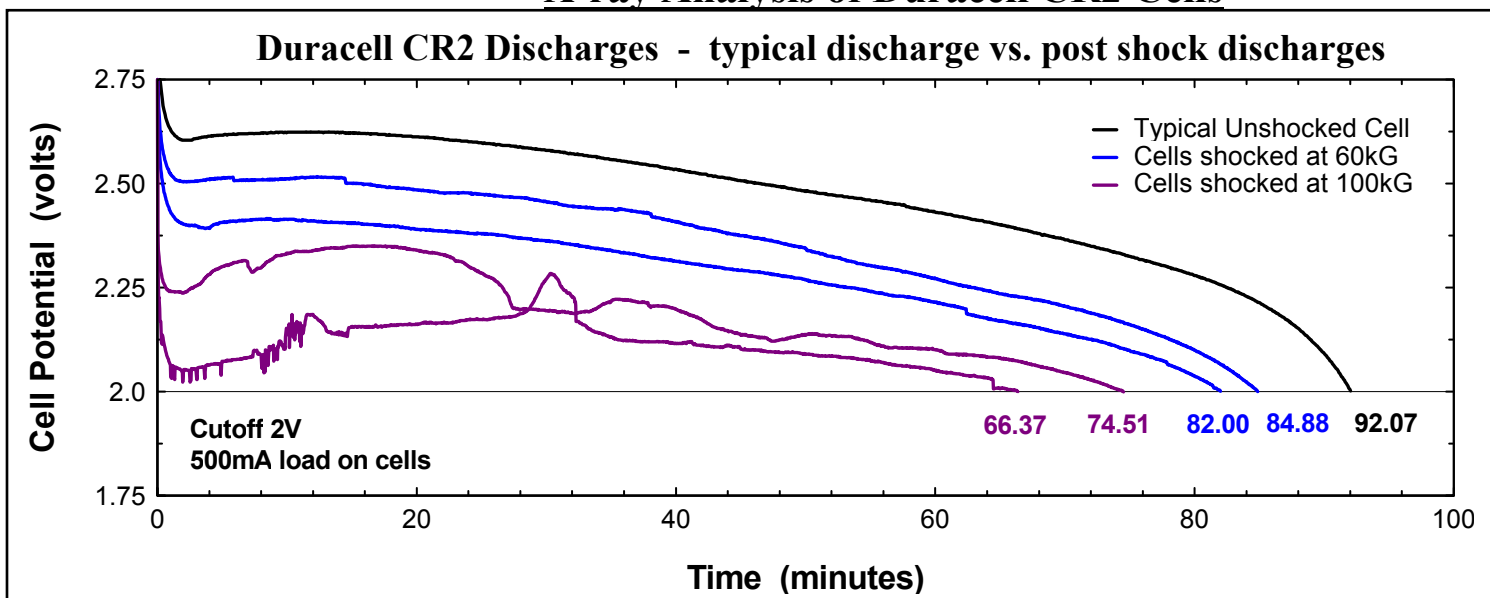


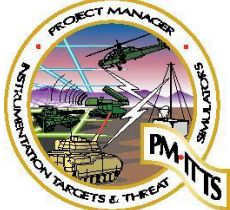
Post 60kG



Post 100kG

X-ray Analysis of Duracell CR2 Cells



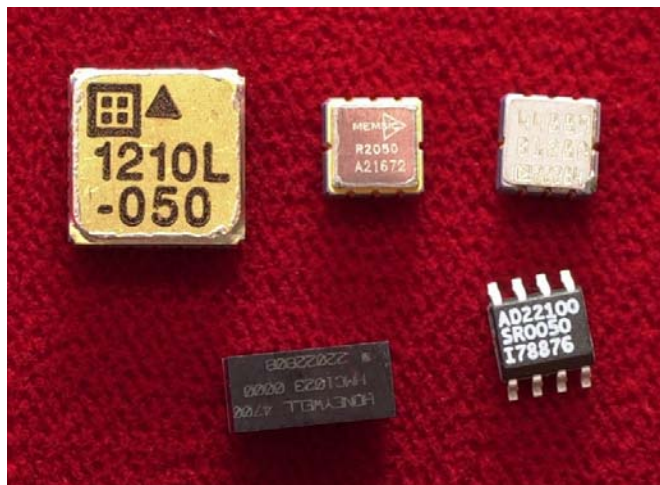


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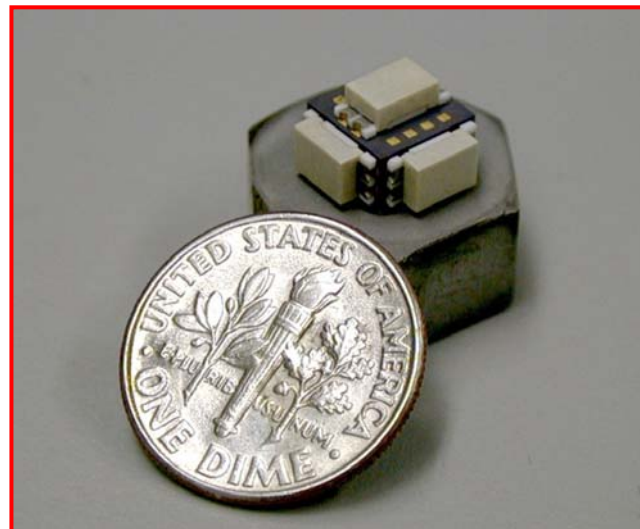


High G Sensors

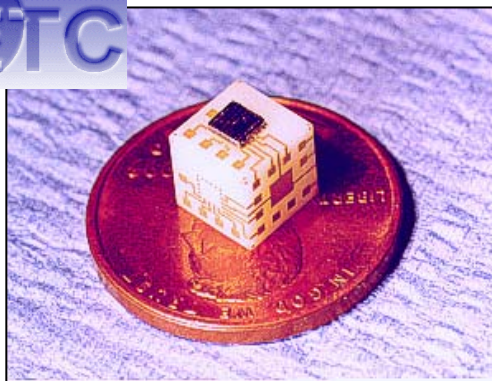
Endevco Model 73



High-G Survivable, Low-Cost, MEMS and other miniature COTS Parts.



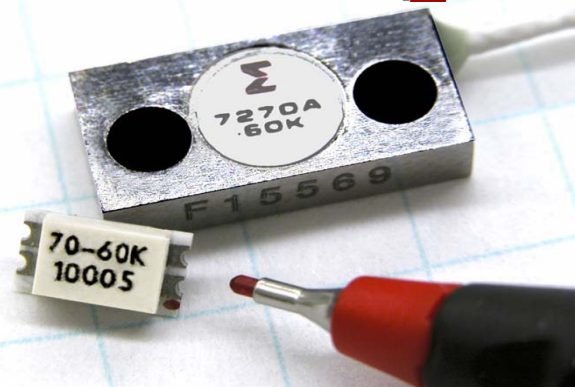
60 k g Accelerometer



100 k g Accelerometer



Model 70 and 7270A (on 1/4" grid)

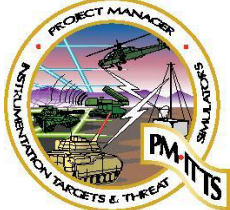


60 k g Accelerometer

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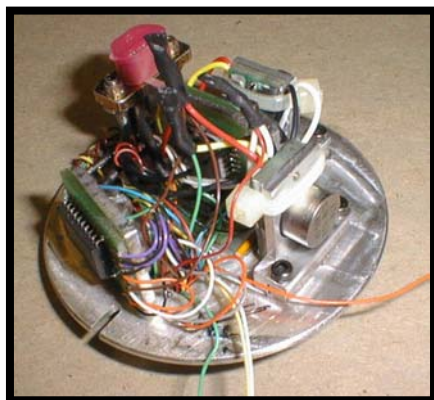
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T&E/S&T EI Projects

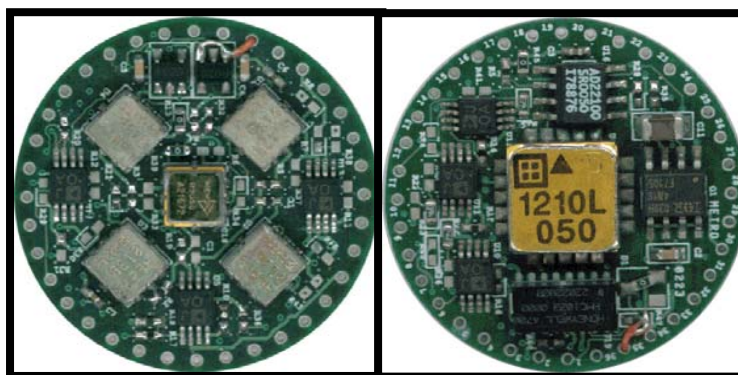
- **MEMS Based Instrumentation for Flight Testing of Advanced Munitions**
 - Leverage ARL's HSTSS telemetry experiences
 - Uses custom MEMS sensors: angular rate, accelerometer, & magnetometer
 - Saves time/\$ in assembly/calibration – may only use 2-3 multi-axis/multi-sensor chips

<u>Sensor Suite Type</u>	<u>Volume (in³)</u>	<u>Power (m-watts)</u>
2.75" Stinger Kit	3.70	800
HSTSS Board	0.30	160
Next Generation	0.03	80



Stinger Sensor Kit ~ 1998

- 4 MEMS accelerometers
- 2-axis GMR magnetometer
- 2 non-MEMS rate sensors

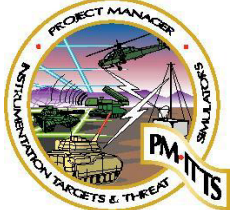


HSTSS Board (bottom/top) ~ 2002

- 3-axis GMR magnetometer
- 4 MEMS accelerometers
- 4 MEMS accelerometers for "spin"
- Temperature sensor for calibration

Multi-Axis
Multi-Instrument
In-Plane
Out-of-Plane
Single/Dual Chip

**Notional Next
Generation Need**



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HSTSS Telemetry Assembly

NATO Fuze Assembly



M/A-COM
Transmitter S-
band

HSTSS/ARL
PCM Encoder

HSTSS
Sensor
Boards

HSTSS Reg.
Board

Antenna

Mortar Fuze Assembly



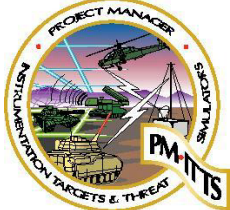
Battery

Contract Awarded to CME

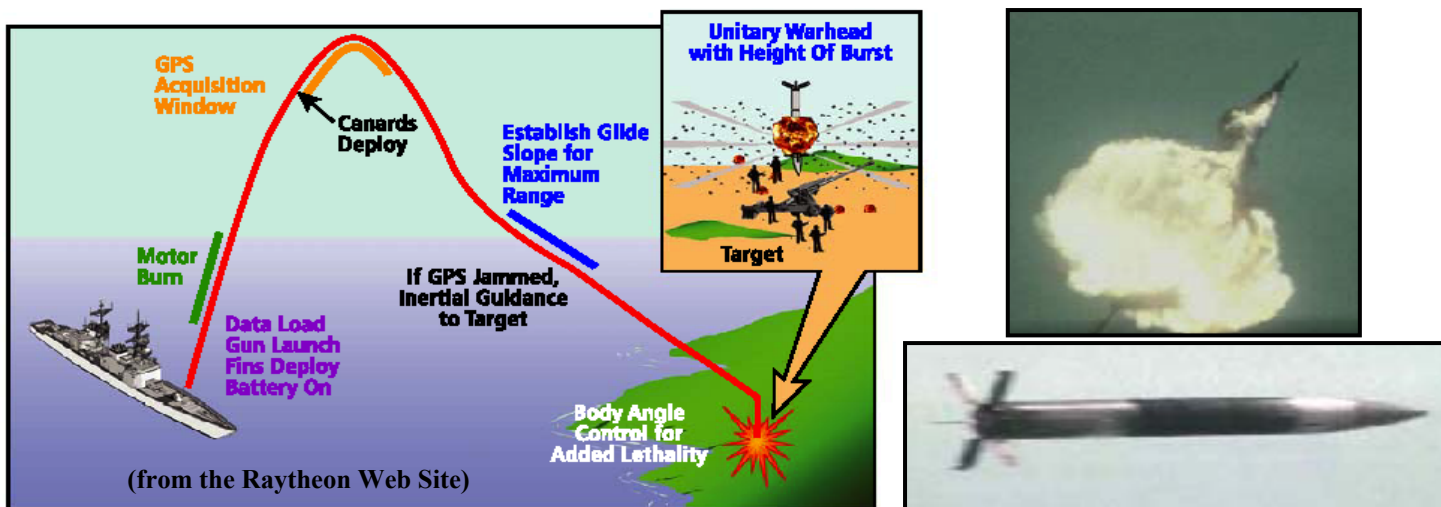
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Embedded Instrumentation for Projectiles Fielded HSTSS



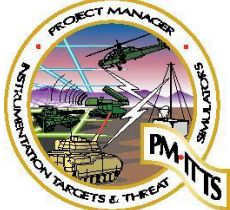
Extended Range Guided Munition (ERGM) - Operational Concept & Flight Tests

- ERGM/PMS-529, Raytheon, and CTEIP's Hardened Subminiature Telemetry & Sensor (HSTSS) Program have teamed to introduce a "non-intrusive" telemetry module
- Estimated cost avoidance due to the reduction of an additional 40 OPEVAL Rounds to ERGM ~ \$2.8M
- Fewer projectiles needed with a single "test/tactical design" concept
- Estimated total cost savings/avoidance ~ \$13M

So don't worry - even difficult EI is here

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Conclusion

- *Technologies are available employ embedded concepts*
- *Include instrumentation as a subsystem during concept formulation*
- *Identify a roadmap on what the instrumentation will be required to do, i.e. lifecycle support needs to be defined*